

**Virgin Islands Water Resources Research Institute
Annual Technical Report
FY 2016**

Introduction

The United States Virgin Islands (USVI) is a Territory of the United States of America and consists of a group of several islands and cays located in the Lesser Antilles which separate the Atlantic Ocean and the Caribbean Sea. The USVI is about 1,200 miles southeast of Miami, Florida and 80 miles east of Puerto Rico. The principal islands in the USVI are St. Croix, St. Thomas, St. John and Water Island. Several of the other smaller islands in recent years have undergone various stages of development. In total, the islands have a combined area of approximately 137 square miles, are of volcanic origin and are mountainous. Tourism is the principal source of support for the economy.

With an annual rainfall of just over 40 inches, the USVI is one of the few places in the world where rain water harvesting is required by law. Buildings are constructed with cisterns that are sized and managed to provide a reliable and relatively safe water supply for users. Because of the hilly terrain, there are virtually no natural surface water supplies. Ground water is limited due to the geology and the risk of salt-water intrusion that could occur from coastal wells. The increasing potable water demands are met largely through use of desalination plants that provide water to the public through water distribution systems. The islands experience challenges in collecting and disposing of wastewater, and water conservation and increasing efficiency in water-use are critical components of effective water resources management in the USVI.

The Virgin Islands Water Resources Research Institute (VI-WRRI) is hosted by the University of the Virgin Islands (UVI). UVI is the Territory's only institution of higher education and has campuses on the islands of St. Croix and St. Thomas and a research station on St. John. It is a Historically Black College or University (HBCU) and a land-grant institution. It was started in 1962. Though UVI is primarily an undergraduate institution, it offers graduate programs in teacher education, business administration, public administration, marine and environmental science and mathematics for secondary education teachers. The University's demographics reflect the local population in that it consists of a diversified mix of USVI residents and persons from the Caribbean region, the United States' mainland and other areas of the world.

The VI WRRI maximizes all resources available to it, to serve the water resources research, information dissemination, and training needs of the people of the U. S. Virgin Islands, that might not be a priority in other settings. It works collaboratively with other units at UVI, territorial agencies, with researchers in the U.S. Geological Survey's Islands Region, and others, to address issues of local, regional, national, and international importance. Areas of focus in the past have included quantity and quality issues of water harvesting, development of alternative on-site sewage disposal systems and non-point source pollution in island environments. This year's projects investigated USVI microclimate variability and climatic shifts, explored potential physical and biological indicators of freshwater gut integrity, and developed educational material to increase U.S. Virgin Islands youth awareness of the importance of water and its conservation.

Research Program Introduction

The Virgin Islands Water Resources Research Institute at the University of the Virgin Islands supported two research projects in the FY2016 VI-WRRI program year. This year's projects supported (1) the U.S. Virgin Islands weather station network which is focused on the delivery of microclimate observations and products, and (2) the potential use of physical and biological parameters as indicators of gut integrity to improve management of these important and understudied ecosystems. Both projects were based on St. Thomas primarily and led by University of the Virgin Islands College of Science & Mathematics faculty, the first project in partnership with a local business.

Ecosystem integrity of riparian waterways on St. Thomas, U.S. Virgin Islands using physical and biological indicators

Basic Information

Title:	Ecosystem integrity of riparian waterways on St. Thomas, U.S. Virgin Islands using physical and biological indicators
Project Number:	2016VI261B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	Not applicable
Research Category:	Biological Sciences
Focus Category:	Ecology, Conservation, Wetlands
Descriptors:	None
Principal Investigators:	Renata J Platenberg

Publications

There are no publications.

Problem and Research Objectives

Natural stormwater drainages, known as “guts” in the U.S. Virgin Islands (USVI), are important riparian corridors with unique ecosystem components that differ from surrounding habitats. Gut systems offer the only natural freshwater resources on St. Thomas, an island that is volcanic in origin with steep slopes and shallow soils (Platenberg 2006). Historic and current land use has altered the hydrology of these waterways such that several guts that once had more permanent stream flow are now dry and retain water in pools only during the rainy season. While the ecological value of these gut systems is recognized, they have been the focus of relatively few ecological studies (e.g., Nemeth and Platenberg 2007, Gardner 2008) and none on the differences between altered (“dry”) and unaltered (“wet”) gut systems.

Typical, measurable water parameters, such as stream flow, dissolved oxygen, temperature, and even pH, are highly variable in these gut systems over both space and time (Benoit & Nemeth, 2011). This has posed a challenge in previous studies that attempted to measure water quality to determine relevant baselines to assist in the management of these systems (Nemeth & Platenberg 2007, Gardner 2008, Benoit & Nemeth 2011). These studies support the need to identify measurable indicators that can reliably detect changes in gut integrity to improve the management of these important freshwater systems.

Two potentially informative indicator types include: (1) physical parameters such as sediment loading, presence/absence and retention of water, and seasonal changes in stream substrate, and (2) biological parameters such as presence/absence of freshwater fish and shrimp in gut pools, composition of vegetation communities, and activity of frogs, bats, birds, and insects within the surrounding riparian habitat.

In order to use these parameters as informative indicators, an understanding of how gut systems differ between wet and dry conditions and across rainy and dry seasons is required. The objective of this study was to identify physical and/or biological differences associated with the presence of water in ephemeral stream systems on St. Thomas, U.S. Virgin Islands. Towards this aim, we also needed to develop appropriate methodology for monitoring these systems, including efficient processing of bioacoustic recordings.

Methodology

Two guts on the northside of St. Thomas were selected for sampling, Neltjeberg and Hendriks (Fig 1). These were surveyed multiple times between August 2016 and February 2017. Transects were established in dry and wet segments of each gut. Physical parameters measured included stream channel characteristics and persistence of water and microhabitat/substrate changes (Fig 2). Biological components measured included stream channel vegetation, tree biodiversity, and activity patterns of bats and birds/frogs/insects using bioacoustics.

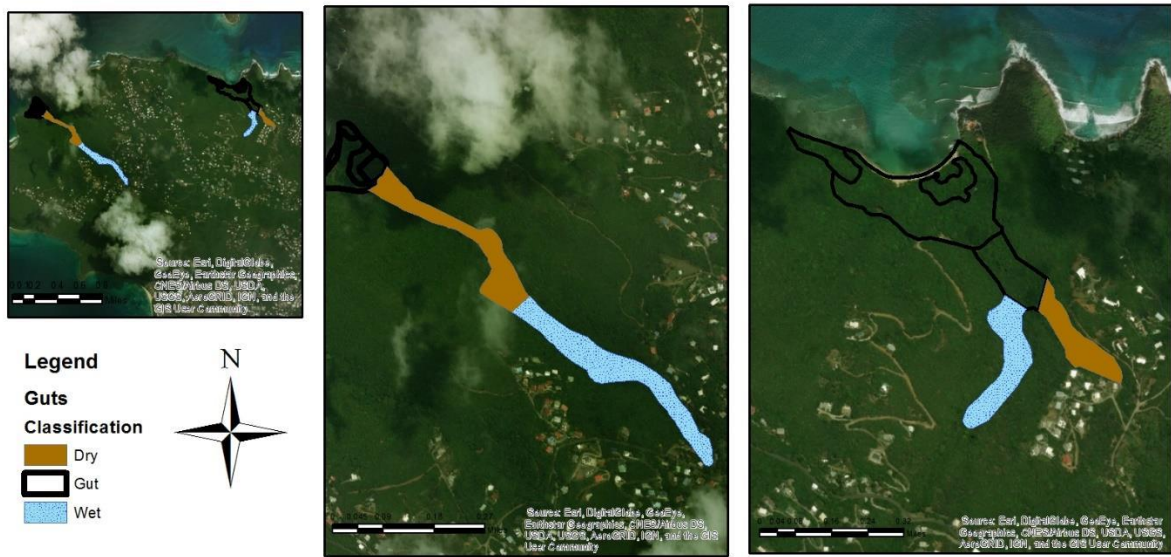


Fig 1. Hendriks and Neltjeberg guts, St. Thomas, U.S. Virgin Islands. “Dry” sampled areas showing in brown, and “wet” sampled areas show in blue. Image created by K. Jerris, 2017.



Fig 2. Measurement of physical characteristics of the gut stream channel.

Bioacoustic recorders were deployed in wet and dry gut segments, and recordings were analyzed using bioacoustics analysis software that visualizes environmental sounds to allow species identification based on shape, frequency, duration, and interval of vocalizations (Fig 3).

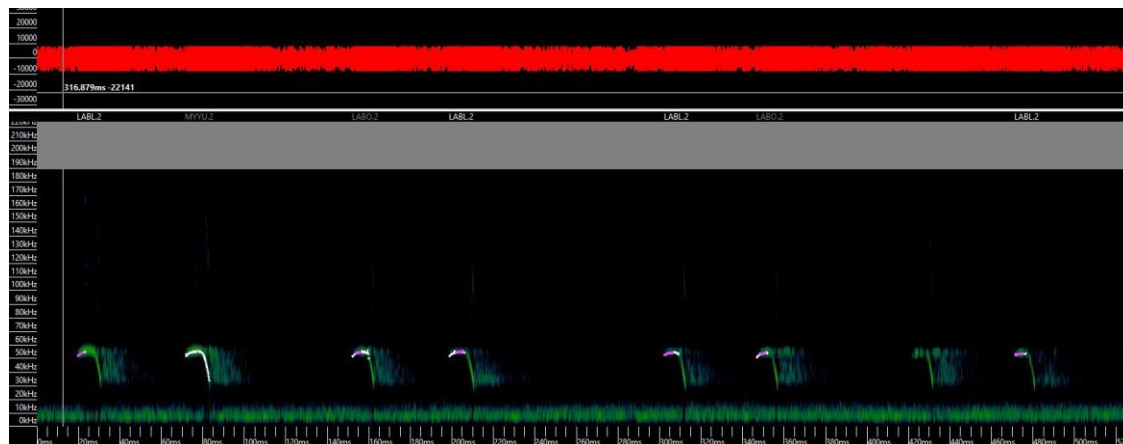


Fig 3. Spectrogram of vocalizations of Greater Bulldog Bat (*Noctilio leporinus*).

Principal Findings and Significance

Physical characteristics of dry and wet segments of the two guts examined showed high variability (Table 1). There were no discernable differences between the two states (wet and dry) in stream channel structure or substrate. Percent cover of water in quadrats and depth of water in pools varied between wet and dry segment and dry and rainy seasons, with wet sections of the stream channels retaining water longer (Fig. 4). There were also no measurable differences in biodiversity of trees between wet and dry guts, although dry guts had more mature vegetative cover within the stream channels due to release of control from flooding. Pools in dry guts did not support freshwater species such as fish and shrimp that were common in wet gut pools.

Table 1. Summary of physical characteristics of stream channels measured in dry and wet segments of Neltjeberg and Hendriks guts. Presence of water is the percentage of all quadrats surveyed that had water cover.

	Neltjeberg				Hendriks			
	Wet		Dry		Wet		Dry	
	Trans 1	Trans 2	Trans 1	Trans 2	Trans 1	Trans 2	Trans 1	Trans 2
Stream channel width (cm) \pm SD	403 \pm 55.5	475 \pm 145.9	884 \pm 143.1	521 \pm 142.1	390 \pm 32.3	365 \pm 56.7	261 \pm 86.4	808 \pm 252
Stream bank height (cm)	125	157	87	18	114	104	109	66
Elevational change (cm)	130	270	160	130	100	100	100	200
Rugosity	0.75	0.66	0.67	0.80	0.79	0.85	0.82	0.75
Presence of water	100%	100%	12%	40%	100%	100%	20%	75%
Vegetation in stream channel	No	Yes	Yes	Yes	No	Yes	Yes	Yes

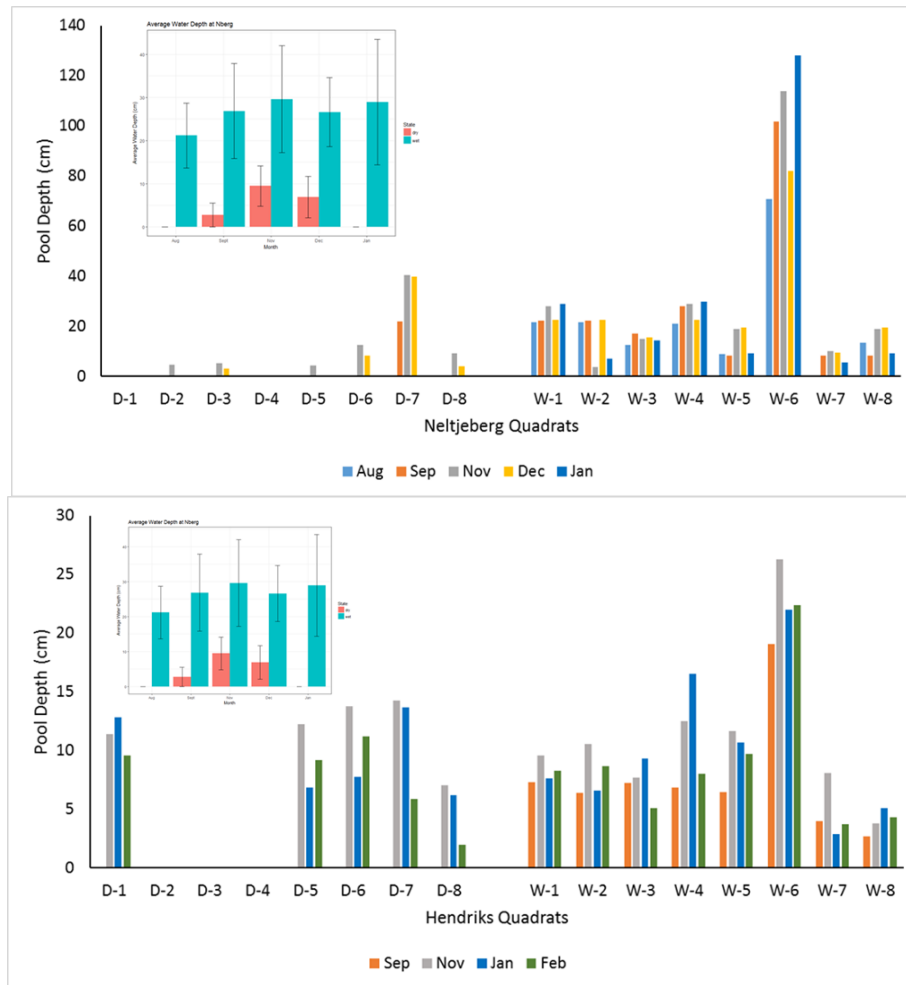


Fig 4. Water depth measured in quadrats across sampling period within dry (D) and wet (W) segments of Neltjeberg gut (top) and Hendriks Gut (bottom). Bars depict average depth taken from five measurements for each quadrat. Inset shows mean water depths across all quadrats by month in dry (pink) and wet (blue) gut segments.

Using bioacoustic data, three species of bats were identified at Neltjeberg and four at Hendriks. The majority of activity was attributed to *Molossus molossus*. *Noctilio leporinus* was documented more frequently in dry guts, while *Molossus* was more abundant in wet guts. *Brachyphylla cavernarum* was documented only in the dry segment in Neltjeberg and only in the wet segment at Hendriks, and *Artibeus jamaicensis* was only identified in one recording from the Hendriks dry segment. Bat activity varied across days (Fig 5), and seemed to respond to localized environmental conditions such as rainfall and moon phase. Metrics for frogs and birds could not be analyzed during this project due to time constraints.

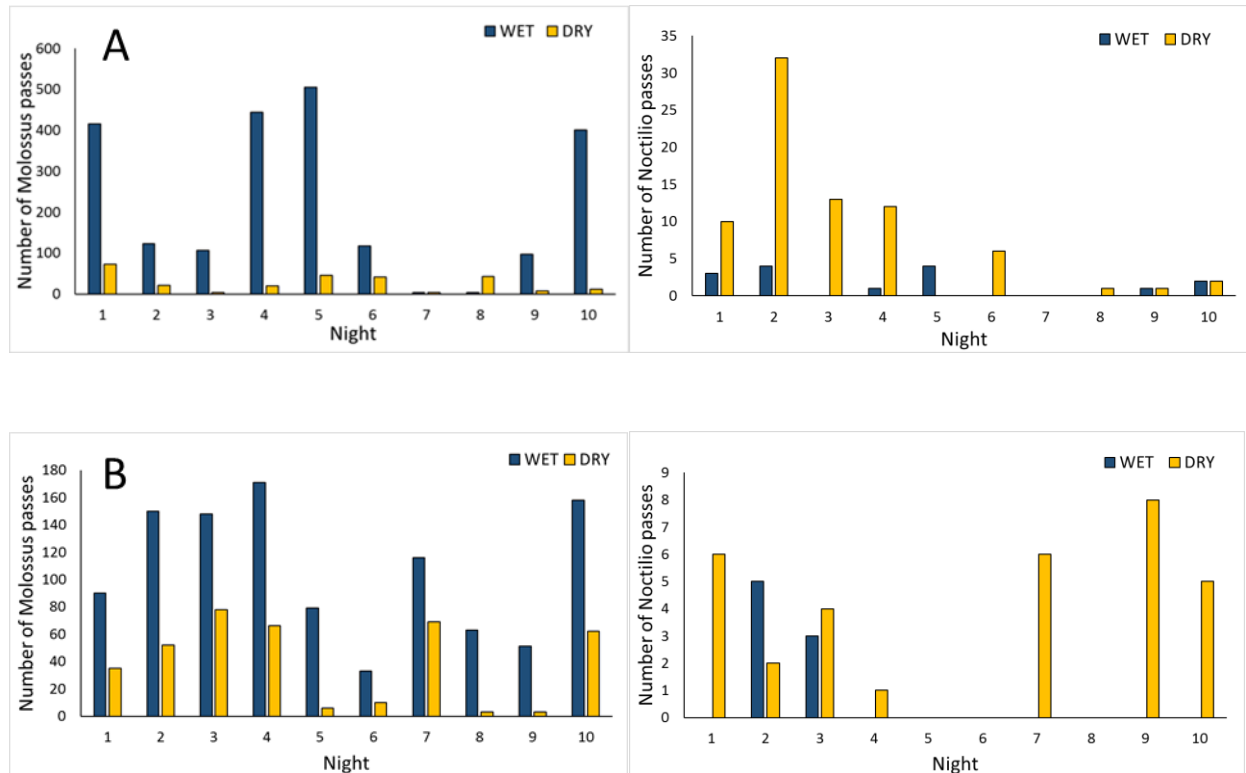


Fig 5. Nightly bat activity at A) Neltjeberg (25 July – 4 August 2016); and B) Hendriks (28 September – 8 October 2016); *Molossus*, left; *Noctilio*, right.

Conclusions

Dry guts are biologically different from wet guts, but these differences are difficult to quantify by assessing physical parameters. The structure between the two systems is visually different and habitat opportunities within the guts vary, with wet guts supporting not only fish and shrimp, but also a riparian vegetation community. Dry guts show mid-stream-channel presence of trees released from control by periodic inundation and scouring. Bioacoustic methods reveal unexpected activity patterns by bats, and can potentially provide insight into habitat use and resource availability for a range of taxa that vocalize.

Monitoring of stream parameters such as water depth and pool size is labor intensive and not particularly informative. Priority should be given to developing alternative monitoring protocols for indicators that can serve as a proxy for water availability, and bioacoustic methods might be useful towards this goal. Soundscape ecology is an emerging field that has the potential for revealing both short-term and long-term species responses to changing environmental conditions (Pijanowski et al. 2011).

References

- Benoit, Gaboury, and Donna Nemeth, 2011, Investigation of Sediment Export from St. Thomas Watersheds, Water Resources Research Institute, University of the Virgin Islands, St. Thomas, U.S. Virgin Islands.
- Gardner, Lloyd, 2008, Changes in Riverine Hydrology on St. Thomas, U.S. Virgin Islands: a pilot study, Water Resources Research Institute, University of the Virgin Islands, St. Thomas, U.S. Virgin Islands, 66 pp.

- Nemeth, Donna, and Renata Platenberg, 2007, Diversity of Freshwater Fish and Crustaceans of St. Thomas Watersheds and its Relationship to Water Quality as Affected by Residential and Commercial Development. Water Resources Research Institute, University of the Virgin Islands, St. Thomas, U.S. Virgin Islands, 34 pp.
- Pijanowski, Bryan C., Luis J. Villanueva-Rivera, Sarah L. Dumyahn, Almo Farina, Bernie L. Krause, Brian M. Napoletano, Stuart H. Gage, and Nadia Pieretti, 2011, Soundscape ecology: the science of sound in the landscape, *BioScience*, 61, 203-216.
- Platenberg, Renata J., 2006, Wetlands Conservation Plan for St. Thomas and St. John, U.S. Virgin Islands, Department of Planning and Natural Resources Division of Fish and Wildlife, St. Thomas, U.S. Virgin Islands, 108 pp.

List of Presentations

Platenberg, Renata, 2017, Soundscape Ecology, Invited talk, University of the Virgin Islands, Masters in Marine and Environmental Science Physical and Ecological Processes Along a Land-Sea Gradient class, St. Thomas, USVI.

Student Participation

- Tucker Stone (Masters first year student), University of the Virgin Islands, Master in Marine and Environmental Science.
- Amelie Jensen (Masters first year student), University of the Virgin Islands, Master in Marine and Environmental Science.
- Kyle Jerris (Undergraduate senior), University of the Virgin Islands, Bachelor of Science in Biology.
- Physical and Ecological Processes Along a Land-Sea Gradient class exercise: “Use of ImageJ in analyzing quadrat percent cover.” Master in Marine and Environmental Science, University of the Virgin Islands, 10 first year Masters students.

Towards Real-Time Microclimate Monitoring in the US Virgin Islands: Optimizing Data Management to Maximize Scientific Production

Basic Information

Title:	Towards Real-Time Microclimate Monitoring in the US Virgin Islands: Optimizing Data Management to Maximize Scientific Production
Project Number:	2016VI263B
Start Date:	3/1/2016
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Congressional District:	Not Applicable
Research Category:	Engineering
Focus Category:	Water Supply, Methods, Models
Descriptors:	None
Principal Investigators:	David C Morris, Norton Brice Orange, Sandra Njeri Maina

Publications

1. Orange, N.B., Chesny, D.C., Maina, S.N., Primack, A.G., Gendre, B., Morris, D.C., Giblin, T.W., 2017, A Recent Climate Study of the Caribbean's Leeward Islands: Implications for a Climatic Shift, Int. J. Climatol., In Review.
2. Orange, N.B., Chesny, D.C., Maina, S.N., Primack, A.G., Gendre, B., Morris, D.C., Giblin, T.W., 2017, A Recent Climate Study of the Caribbean's Leeward Islands: Accessing a Sun -- Tropical North Atlantic Ocean -- Local Tropical Climate Connectivity, Int. J. Climatol., In Review.

Problem and Research Objectives

Evidence is rapidly emerging that the global climate is warming and hydrological cycles are strengthening (e.g., Folland et al. 2001, Alexander et al. 2006, Tselioudis et al. 2010, Donat et al. 2013, Tan et al. 2015). More accurate and reliable climate data are informing models and our understanding of these changes, with a notable exception of the Lesser Antilles Caribbean Basin where data are less uniformly available. As small Island States are predicted to serve as early warning systems for climate change, and many Caribbean islands are currently attempting to address vulnerabilities, a strategic and essential need exists for dedicated monitoring of the U.S. Virgin Islands' (USVI) microclimates to: (1) enable scientific study of the Caribbean climatology, (2) support safety and stability of residential water supplies and (3) facilitate a deeper understanding of feedbacks between terrestrial and near-shore marine ecosystems.

The development of tools to ensure long-term consistent operation of the USVI weather stations, such as software infrastructure for end-to-end management of environmental data, and analytic tools for identifying and classifying precursor signals of short- and long-term climate modulations, remains a critical need. Similarly, though significant progress has been made towards a more complete classification of the Caribbean climate, gaps remain for the USVI.

Our work encompassed four objectives that represent fundamental work towards meeting the critical needs of the USVI weather station network, formulating a more complete understanding of the Caribbean climate classification, and contributing to a comprehensive understanding of its relationship to the global climate environment. Our goal is the delivery of sustainable microclimate observations and products that will enable scientific and objective assessments of a climatically sensitive tropical island region, and the formulation of a more complete understanding of climate change and its subsequent economic, social, and ecological sustainability. We have four major thrusts:

- Critical management provisions that maximize the project's operational lifetime
- Improved accessibility and usability of the USVI digital environmental data records
- Details of the energetic coupling of USVI climate signals to global variability nodes
- Improvement of tropical logic and limitations of historical climate studies

We report on the above thrusts by first detailing the work completed over the course of this project, which are immediately followed-up by our recommendations and planned future work. In relation to the latter, though extensive in detail, we emphasize the following. The foundation works completed, and initiated by this project, represent only the first in an evolution towards a USVI microclimate monitoring program adhering to the fundamental protocols of scientific data stewardship. A task whose continuation is pivotal to the future of a program that, at the onset of this project, asserted no quality control and minimal follow-up on hardware related malfunctions, and relied on commercial proprietary software and on-line serves for data collection, and storage, respectively.

Methodology

Tropical Island Microclimate Monitoring -- Hardware Logistics

This component of our project represents work towards the development of a system-wide monitoring program dedicated to hardware and data protocols that ensure consistent operating procedures. Critical management provisions that are crucial to the stations' hardware logistics and maximizing their operational lifetimes have been developed. Our long term goal for

this thrust of the USVI microclimate monitoring program is the development of a suite of standard operating procedures (SOPs) for station site selection, installation, programming setup, calibration (both initial and routine), and maintenance schedules. Its central focus is to result in the best hardware management and data-handling practices that minimize the potential of station failures and data anomalies from systematic degradations.

In Table 1, we detail the USVI weather stations deployed by our research group. The Davis Vantage Vue (DVV) and Davis Vantage Pro2 (DVP2) based meteorological weather stations consist of two components: a compact outdoor sensor array (OSA) and an indoor console. The OSA wirelessly sends temperature, precipitation, relative humidity, wind speed and wind direction information to the console at a range of up to 300m, on time-scales of approximately a few seconds to about a minute.

Table 1. List of St. Thomas, USVI Davis meteorological weather stations including their type, geographic location, elevation, age, and period of data collection. Note that period NA's denote stations where data streams downloads are currently blocked by internet security protocols.

Island	Station Name	Station Type	Latitude (°N)	Longitude (°W)	Elevation (ft) (ft)	Age (Months)	Period (Str – End)
Saint Thomas	Botany Bay	Vantage Vue	18.354	-65.018	340	10	2014 – Pres
	Etelman Observatory	Vantage Pro2	18.354	-64.966	1250	48	NA
	Coral World	Vantage Vue	18.338	-64.853	20	27	2014 – Pres
	Pink Whale	Vantage Vue	18.359	-64.950	1100	34	2012 – Pres
	Neltjeberg	Vantage Vue	18.368	-64.975	550	30	2014 – Pres
	Antilles	Vantage Vue	18.325	-64.909	320	27	2014 – Pres
	Cowpet Bay	Vantage Vue	18.318	-64.843	80	27	2014 – Pres
	UVI	Vantage Vue	18.342	-64.972	80	26	2014 – Pres
	Tutu/Mandal	Vantage Vue	18.359	-64.894	60	27	2014 – 2015
	Oliver Benjamin	Vantage Vue	18.337	-64.888	242	10	NA
	All Saints	Vantage Vue	18.345	-64.932	30	9	NA
	Cancryn	Vantage Vue	18.337	-64.946	37	9	2015 – Pres
	Eudora Kean	Vantage Vue	18.325	-64.853	45	9	NA
	Montessori	Vantage Vue	18.321	-64.853	40	9	NA

Tropical Island Microclimate Monitoring -- Software Logistics

This component of our project represents work towards the development of data discovery and management methodologies that will, ultimately, optimize the scientific return and educational effectiveness of the USVI weather stations (Table 1). Our long term goal for this thrust is to provide the critical tools that will improve the accessibility and usability of USVI environmental data records, and that will integrate rapidly-emerging computer science and big data analytic techniques designed for expanding data volumes to maximize their scientific returns.

Our work-to-date and future plans are rooted in a paradigm shift of current USVI weather station data-handling practices, from the historically used human intensive analysis and simple spreadsheet statistics to automated data-processing tools. Central to our work-to-date has been the development and integration of dynamic data and meta-data collection, management, storage, and analyses software frameworks, that can streamline their integration across broadened spatiotemporal scales from meteorological weather stations and/or historical environmental digital records.

Tropical Island Climate Analytics

This component of our project represents work towards advancing our understanding of the coupling of the USVIs' climate feedbacks with the mechanisms driving global variability. In particular, we studied the Leeward Islands recent decadal (1952--2014) climate in order to advance our understanding of its past and future climate mitigations through statistical and demographic analyses of its energetic coupling to the Atlantic Multidecadal Oscillation (AMO) and sunspot numbers, as a means to decipher their role in driving local climate signal uptake; work-to-date that is currently in submission to the *International Journal of Climatology*. Our long-term goal for this thrust is to formulate a more complete Caribbean climate classification, and contribute to the development of a comprehensive understanding of its relationship to the global climate environment.

In relation to this component of our project's work-to-date, particularly the global variability nodes selected for a connectivity analyses to the Leeward Islands climate, we wish to expound upon the following. Global drivers, such as the El-Nino Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), and Atlantic Multidecadal Oscillation (AMO) indices, have shown robust signals within the Caribbean climate (Hastenrath 1976; Rogers 1988; Malmgren et al. 1998; George and Saunders 2001; Enfield et al. 2001), particularly through strong correlations with North Atlantic Sea Surface Temperature (SST) oscillations. This leads to considerations that North Atlantic-driven SST fluctuations prevail as the dominant global to local Caribbean climate uptake mechanism, which aligns with the region's oceanic trade wind dominance (Malmgren et al. 1998; George and Saunders 2001). Given that Stephenson et al. (2014) only recently showed significant temperature to AMO correlations, the need for further detailed investigations is elevated.

Solar forcing is known to maximize tropical stratospheric and tropospheric changes via atmospheric chemistry processes (Haigh 1999), which leak down to surface layers as enhanced pressure and temperature gradients, and resemble positive North Atlantic Oscillation-like (NAO) patterns (e.g., Shindell et al. 1999a, Shindell et al. 1999b, Koder and Kuroda 2002). Thus, such external atmospheric forcing enhances tropical SSTs through NAO activity excitations, whose heating of the Atlantic water's energy reservoir has been revealed to temporally lag solar variability (e.g., Cubasch et al. 1997, Waple et al. 2002, Kobashi et al. 2015). Leveraging these notions with the emerging evidence implicating the 1950s--1980s era of enhanced solar activity (Steinhilber et al. 2012) as a driver of recent Greenland cooling (e.g., Kobashi et al. 2011, Kobashi et al. 2013, Kobashi et al. 2015) elevates the interest for a local Caribbean climate to solar coupling exploration study, in particular as a tool for advancing our knowledge of the Caribbean climate classification, and increasing our understanding of atmospheric energy redistribution processes.

Tropical Island Microclimate Monitoring -- Logic and Limitations

Our project increases the transparency of our USVI microclimate monitoring program and has developed software frameworks to simplify the expansion of our techniques across broadened spatiotemporal scales. Our work-to-date is the cornerstone of our planned future work to address the utility of geographically-standardized logic and limitations when detailing historical climate records.

We have highlighted the standard quality controls of tropical GHCN climate records, and the fact that most often in historical climate studies such is implemented within automated data-processing tools (e.g., RCLimDex). That these tools eliminate the user's final binary decision to

decipher whether to remove or keep suspect time series and/or spatial perspectives, and adhere to a spatiotemporally standardized logic, elevates questions to their validity in data management and scientific provision gains. Despite the abundant problems encountered in historical archives (Peterson et al. 1998) and active monitoring programs (e.g., our USVI microclimate program), what are the most accurate quality controls, and subsequent logic and limitations, that best mitigation scenarios in which small upstream anomalies lead to large downstream inaccuracies in their indices of extreme climate variability.

Principal Findings and Significance

We find support from the Leeward Islands' recent decadal climate variability for an approximate 1980s Caribbean climate shift. We observed in the temperature minima indices diurnal temperature range (Fig 1), the annual number of consecutive dry and wet days and an account of the intensity of annual daily rainfall highlight that the 1980s correlates with a shift in the indices polarity, when convolved about a running mean.

To quantitatively identify a climatic shift, we assumed the null hypothesis that a degree of noise existed in the station temperature and precipitation data and measured their absolute minima (i.e., closest zero epoch in the mean convolutions) using linear least square regression fits during four different bootstrap resamplings. It is emphasized that in addition to seeking to account for noise in our climate data (Alexander et al. 2006), the 25 bootstrapped fields generated by these perturbations per extreme climate index represent the same object computed under various physical (temporal) constraints (Orange et al. 2016), and as such, they include weighting from non-statistical uncertainties (e.g., period selection biases).

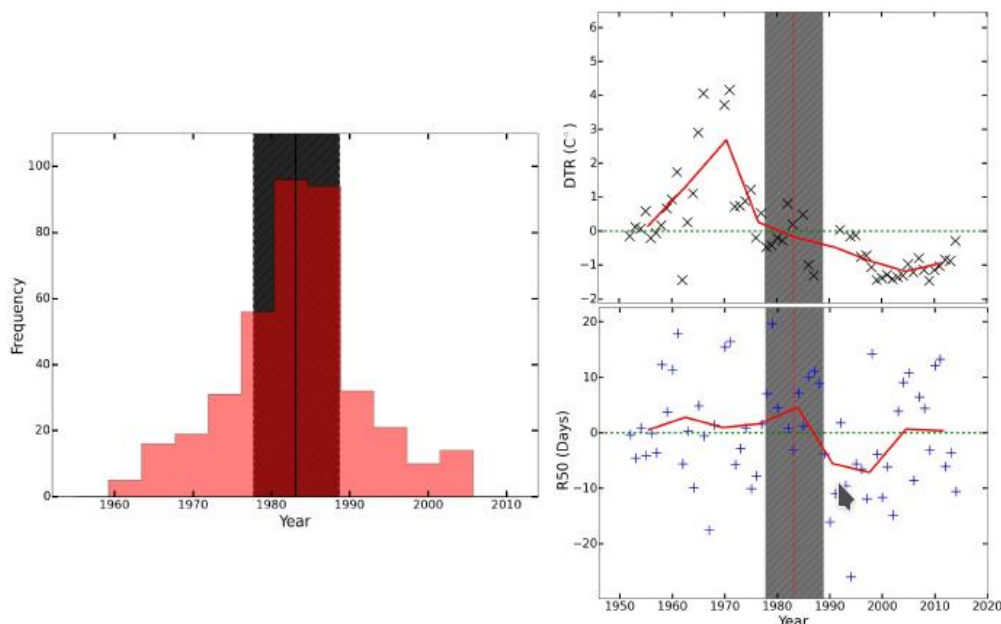


Fig 1. Top: Histogram of all RCLimDex indices' identified climatic shift. Annual DTR and R50 (top to bottom respectively) RCLimDex indices during 1952-2014, where plotted points reflect the annually derived indices and the solid (red) line represents their seven point (year) running means. Note our derived climatic shift has been shown on each plot.

We averaged across all index climatic shift re-samplings in order to define the Leeward Islands climatic shift. Its uncertainty was propagated as the sum of said ensembles 1-sigma deviation with the average propagated linear fit coefficient uncertainty, obtained per index. From this approach 1983.5 +/- 5.5 yrs was identified as the shift period, and we explored deriving a climatic shift via averaging random subsets of the original 400 bootstrapped fields; an aspect that lead to only marginally different conclusions, which fell within the original period's uncertainty. In relation to a Leeward Islands' climatic shift, we emphasize that this quantitatively measured period aligns well with those inferred qualitatively from local (Beharry et al. 2014), regional (Peterson et al. 2002, Taylor et al. 2002, Aguilar et al. 2005, Stephenson et al., 2014), and global (Alexander et al. 2006, Tselioudis et al. 2010, Donat et al. 2013, Tan et al. 2015) reports. As such, we find confidence that our Leeward Islands' climatic shift provides a good first order approximation to a recent shift in our study area's climate.

Conclusions

Our work has: (1) advanced the management provisions of a USVI microclimate monitoring program and developed a roadmap to maximize the project's operational lifetime, (2) improved the digital environmental data records of the USVI microclimate monitoring program, (3) contributed to a more complete classification of the Caribbean climate and highlighted the ability of local climate studies to enhance our understanding of large-scale atmospheric-ocean energy redistribution processes, and (4) laid the foundation for near-term studies on the feasibility of standardized logic in historical studies of extreme tropical climate variability.

We have initiated the development of a system-wide monitoring program dedicated to hardware and data protocols that will ensure consistent operating procedures of the USVI microclimate monitoring programs. Work that was driven by our preliminary in-field studies of the sensor microclimate reporting accuracies in new, and existing USVI weather stations. These studies revealed the necessity and importance of routine hardware inspections, maintenance, and systematic data practices, as their results highlighted the fact that within two years of field activation, stations experienced significant systematic degradations in sensor accuracies. Thus, pertinent to maximizing its operational lifetime is the continuation of the work developed herein, in particular the construction of standard operation procedures (SOPs) for weather station site selection, installation (developed through this project), programming setup, calibration (both initially and routine), and maintenance schedules. As a continuation of our work towards a long-term goal to provide the best hardware management and data-handling practices that minimize the potential of station failures and data anomalies from systematic degradations, the following near-term goals were presented: (1) developing SOPs for identifying and coping with hardware malfunctions, (2) developing maintenance and station calibration SOPs, and (3) working towards forecasting critical management provisions.

This project laid the foundation for completing a paradigm shift in current USVI weather station data-handling practices, from: a lack of data quality controls; management via commercial proprietary software; and reliance on human intensive analysis using simple spreadsheets, to one rooted in the techniques of scientific data stewardship and the implementation of rapidly-emerging computer science and big data analytic techniques designed for expanding data volumes. We have developed an autonomous, transparent, data quality control algorithm for multiple types of historical climate records (i.e., GHCN and the USVI microclimate monitoring program). We constructed software designed to assess nonstatistical and statistical uncertainties in studies of historical extremes of climate variability, using records

containing climate noise. Methodologies that we showed not only improved the logic and limitations of extreme climate indices' evidence of long-term climate modulations, but highlighted the necessity of using varying physical constraints for ascertaining uncertainties in climate trends, which in large part remains uncommon in previous works. We constructed USVI microclimate monitoring data collection daemons that represented a factor of 1000 improvement over existing techniques, and vastly improved the project's sustainability and transparency. Using these results, we presented, as our recommendations, a near-term roadmap that would significantly contribute to achieving our goal of comprehensive end-to-end stewardship practices in the USVI microclimate monitoring program's digital environmental records.

References

- Aguilar, E., T. Peterson, P. Obando, R. Frutos, J. Retana, M. Solera, J. Soley, I. García, R. Araujo, A. Santos, V. Valle, M. Brunet, L. Aguilar, L. Álvarez, M. Bautista, C. Castañón, L. Herrera, E. Ruano, J. Sinay, E. Sánchez, G. Oviedo, F. Obed, J. Salgado, J. Vázquez, M. Baca, M. Gutiérrez, C. Centella, J. Espinosa, D. Martínez, B. Olmedo, C. Espinoza, R. Núñez, M. Haylock, H. Benavides, R. Mayorga, 2005, Changes in precipitation and temperature extremes in Central America and northern South America, 1961-2003. *Journal of Geophysical Research (Atmospheres)* 110, D23107.
- Alexander, L.V., X. Zhang, T. Peterson, J. Caesar, B. Gleason, A. Klein Tank, M. Haylock, D. Collins, B. Trewin, F. Rahimzadeh, A. Tagipour, K. Rupa Kumar, J. Revadekar, G. Griffiths, L. Vincent, D. Stephenson, J. Burn, E. Aguilar, M. Brunet, M. Taylor, M. New, P. Zhai, M. Rusticucci, J. Vazquez-Aguirre, 2006, Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research (Atmospheres)* 111.
- Beharry, S.L., R. Clarke, K. Kumarsingh, 2014, Variations in extreme temperature and precipitation for a Caribbean island: Trinidad. *Theoretical and Applied Climatology* 122(3), 783 – 797.
- Cubasch, U., R. Voss, G. Hegerl, J. Waszkewitz, T. Crowley, 1997, Simulation of the influence of solar radiation variations on the global climate with an ocean-atmosphere general circulation model. *Climate Dynamics* 13, 757 – 767.
- Donat, M.G., L. Alexander, H. Yang, I. Durre, R. Vose, R. Dunn, K. Willett, E. Aguilar, M. Brunet, J. Caesar, B. Hewitson, C. Jack, A. Klein Tank, A. Kruger, J. Marengo, T. Peterson, M. Renom, C. Oria Rojas, M. Rusticucci, J. Salinger, A. Elayah, S. Sekele, A. Srivastava, B. Trewin, C. Villarroel, L. Vincent, P. Zhai, X. Zhang, S. Kitching, 2013, Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The hadex2 dataset. *Journal of Geophysical Research: Atmospheres* 118(5), 2098 – 2118.
- Enfield, D.B., A. Mestas-Nuez, P. Trimble, 2001, The Atlantic multidecadal oscillation and its relation to rainfall and river flows in the continental U.S. *Geophysical Research Letters* 28(10), 2077 – 2080.
- Folland, C., T. Karl, J. Christy, R. Clarke, G. Gruza, J. Jouzel, M. Mann, J. Oerlemans, M. Salinger, and S. Wang, 2001, Observed Climate Variability and Change, Contribution of Working Group I to the IPCC Third Assessment Report, Cambridge University Press, Cambridge, 99-181
- George, S.E. and M. Saunders, 2001, North Atlantic oscillation impact on tropical north Atlantic winter atmospheric variability. *Geophysical Research Letters* 28(6), 1015 – 1018.

- Haigh, J.D., 1999, A GCM study of climate change in response to the 11-year solar cycle. *Quarterly Journal of the Royal Meteorological Society* 125(555), 871 – 892.
- Hastenrath, S., 1976, Variations in low-latitude circulation and extreme climatic events in the tropical Americas. *Journal of the Atmospheric Sciences* 33(2), 202 – 215.
- Kobashi, T., K Kawamura, J. Severinghaus, J. Barnola, T. Nakaegawa, B. Vinther, S. Johnsen, J. Box, 2011, High variability of Greenland surface temperature over the past 4000 years estimated from trapped air in an ice core. *Geophys. Res. Lett.* 38, L21501.
- Kobashi, T., D. Shindell, K. Kodera, J. Box, T. Nakaegawa, K. Kawamura, 2013, On the origin of multidecadal to centennial Greenland temperature anomalies over the past 800 yr. *Climate of the Past* 9(2), 583 – 596.
- Kobashi, T., J. Box, B. Vinther, K. Goto-Azuma, T. Blunier, J. White, T. Nakaegawa, C. Andresen, 2015, Modern solar maximum forced late twentieth century Greenland cooling. *Geophysical Research Letters* 42(14), 5992 – 5999.
- Kodera, K., Y. Kuroda, 2002, Dynamical response to the solar cycle. *Journal of Geophysical Research (Atmospheres)* 107,4749.
- Malmgren, B.A., A. Winter, D. Chen, 1998, El nino southern oscillation and north Atlantic oscillation control of climate in Puerto Rico. *Journal of Climate* 11(10), 2713 – 2717.
- Orange, N.B., D. Chesny, B. Gendre, D. Morris, H. Oluseyi, 2016, Solar Atmospheric Magnetic Energy Coupling: Broad Plasma Conditions and Spectrum Regimes. *Astrophys. J.*, Accepted.
- Peng, G., Privette, J.L., Kearns, E.J., Ritchey, N.A., Ansari, S.: 2015, A unified framework for measuring stewardship practices applied to digital environmental datasets. *Data Science Journal* 13, 231 – 253. doi:10.2481/dsj.14-049.
- Peterson, T.C., R. Vose, R. Schmoyer, V. Razuvaev, 1998, Global historical climatology network (ghcn) quality control of monthly temperature data. *International Journal of Climatology* 18(11), 1169 – 1179.
- Peterson, T.C., M. Taylor, R. Demeritte, D. Duncombe, S. Burton, F. Thompson, A. Porter, M. Mercedes, E. Villegas, R. Semexant Fils, A. Klein Tank, A. Martis, R. Warner, A. Joyette, W. Mills, L. Alexander, B. Gleason, 2002, Recent changes in climate extremes in the Caribbean region. *Journal of Geophysical Research: Atmospheres* 107(D21), ACL16-1–ACL 16-9.
- Rogers, J.C.: 1988, Precipitation variability over the Caribbean and tropical Americas associated with the southern oscillation. *Journal of Climate* 1(2), 172 – 182.
- Shindell, D.T., R. Miller, G. Schmidt, L. Pandolfo, 1999a, Simulation of recent northern winter climate trends by greenhouse-gas forcing. *Nature* 399, 452 – 455.
- Shindell, D., D. Rind, N. Balachandran, J. Lean, P. Lonergan, 1999b, Solar Cycle Variability, Ozone, and Climate. *Science* 284, 305
- Steinhilber, F., J. Abreu, J. Beer, I. Brunner, M. Christl, H. Fischer, U. Heikkila, P. Kubik, M. Mann, K. McCracken, H. Miller, H. Miyahara, H. Oerter, F. Wilhelms, 2012, 9,400 years of cosmic radiation and solar activity from ice cores and tree rings. *Proceedings of the National Academy of Science* 109, 5967 – 5971.
- Stephenson, T.S., L. Vincent, T. Allen, C. Van Meerbeeck, N. McLean, T. Peterson, M. Taylor, A. Aaron-Morrison, T. Auguste, D. Bernard, J. Boekhoudt, R. Blenman, G. Braithwaite, G. Brown, M. Butler, C. Cumberbatch, S. Etienne-Leblanc, D. Lake, D. Martin, J. McDonald, M. Ozoria Zaruela, A. Porter, M. Santana Ramirez, G. Tamar, B. Roberts, S. Sallons Mitro, A. Shaw, J. Spence, A. Winter, A. Trotman, 2014, Changes in extreme

- temperature and precipitation in the caribbean region, 1961-2010. *International Journal of Climatology* 34(9), 2957 – 2971.
- Tan, J., C. Jakob, W. Rossow, G. Tselioudis, 2015, Increases in tropical rainfall driven by changes in frequency of organized deep convection. *Nature* 519, 451 – 454.
- Taylor, M.A., D. Enfield, A. Chen, 2002, Influence of the tropical Atlantic versus the tropical Pacific on Caribbean rainfall. *Journal of Geophysical Research: Oceans* 107(C9), 10-1-10-14.
- Tselioudis, G., E. Tromeur, W. Rossow, C. Zerefos, 2010, Decadal changes in tropical convection suggest effects on stratospheric water vapor. *Geophysical Research Letters* 37(14).
- Waple, A.M., M. Mann, R. Bradley, 2002, Long-term patterns of solar irradiance forcing in model experiments and proxy based surface temperature reconstructions. *Climate Dynamics* 18, 563 – 578.

List of Presentations

- Orange, N.B., Maina, S.N., 2016, Toward Microclimate Monitoring in the U.S. Virgin Islands, Talk, Weather Summit, Etelman Observatory, St. Thomas, USVI.
- Thomas, K., Maina, S., Orange, N.B., Morris, D.C., 2016, Microclimate Monitoring in the U.S. Virgin Islands: Towards Real-Time Data Management Analytics, Emerging Caribbean Scientist Conference, St. Thomas, USVI.
- Stolz, N., Orange, N.B., 2016, Microclimate Monitoring in the U.S. Virgin Islands: Towards Real-Time Data Collection and Management Analytics, Emerging Caribbean Scientist Conference, St. Thomas, USVI.
- Morris, D.C., 2016, Monitoring Climate in the USVI, Invited Talk, USVI Drought Monitor Forum, St. Croix, USVI.
- Orange, N.B., 2017, A Recent Climate Study of the Caribbean's Leeward Islands – Implications for a Climatic Shift, Lunch N' Talk open to Water Ambassadors Program, Environmental Protection Agency, and University of Puerto Rico Mayaguez.

List of Publications

- Orange, N.B., Chesny, D.C., Maina, S.N., Primack, A.G., Gendre, B., Morris, D.C., Giblin, T.W., 2017, A Recent Climate Study of the Caribbean's Leeward Islands: Implications for a Climatic Shift, *Int. J. Climatol.*, *In Review*.
- Orange, N.B., Chesny, D.C., Maina, S.N., Primack, A.G., Gendre, B., Morris, D.C., Giblin, T.W., 2017, A Recent Climate Study of the Caribbean's Leeward Islands: Accessing a Sun -- Tropical North Atlantic Ocean -- Local Tropical Climate Connectivity, *Int. J. Climatol.*, *In Review*.

Student Participation

- Calwyn Morton (Junior), UVI, Biology in College of Science and Mathematics.
- Kryelle Thomas (Sophomore), UVI, Physics in College of Science and Mathematics.
- Noah Stolz (Sophomore), Rensselaer Polytechnic Inst, Comp Sci in Computer Science Department.

Information Transfer Program Introduction

One VI-WRRI project was supported through the Information Transfer Program during the 2016-2017 program year: the Water Ambassador Program II. Support from 104b funding resulted in educational material and programming that increased awareness of the importance of water and its conservation among USVI elementary and middle school students. Important to note, however, is that all projects conducted through the VI-WRRI are required to include elements of information dissemination and training in their activities. This was done and is evident through the public presentations that were made and the numerous students, both graduate and undergraduate, that participated in the research projects.

Water Ambassador Program II

Basic Information

Title:	Water Ambassador Program II
Project Number:	2016VI260B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	Not Applicable
Research Category:	Climate and Hydrologic Processes
Focus Category:	Water Supply, Conservation, Water Quantity
Descriptors:	None
Principal Investigators:	christina marie chanes, Avram Gerald Primack

Publications

There are no publications.

Problem and Research Objectives

The United States Virgin Islands (USVI) is a small territory just to the east of Puerto Rico that consists of three main islands, St. Thomas, St. Croix, and St. John, and a few smaller, mostly unpopulated islands. The majority of the people in the Territory live on St. Croix and St. Thomas. St. John and Water Island have fewer people. In addition to permanent residents, St. Thomas is one of the busiest tourism destinations in the Caribbean (Allen 1992) with more than 2 million visitors annually in recent years (USVI BER 2012). A significant proportion of the population of these islands draws their water from cisterns that collect rooftop water. The rest are dependent on groundwater sources. Everyone must purchase water purified in reverse osmosis when there are no other sources. Because of the small size of the islands, surface water supplies are limited and the availability of groundwater supplies is restricted by high relief and small aquifers. Most residents away from major towns rely on gathering rainwater from their personal rooftop into cisterns that they maintain themselves. Streams only flow for short periods after rainfall, are nearly dry for the rest of the year, and are heavily impacted by roads and erosion from poor construction practices high in their watersheds. All of these forces place great stress on natural hydrologic systems throughout the Territory and on St Thomas in particular.

There continues to be a great need for education about water resources and their management in the USVI. There is also need for data collection on the status of streams and watersheds and increased understanding of climate patterns on the island. The Water Ambassador Program (WAP) is a model educational program that introduces Virgin Islands youth to water and landscape conservation practices, creates a system for collecting crowd source data (data collected by the public through a web mapping interface) on the status of hydrologic systems in the Territory using these students to report on their own watersheds, and increases the network of weather stations currently operated by the University of the Virgin Islands (UVI) by bringing a station to each participating school. In its first year, the WAP reached over 350 students in the 6th -12th grades from seven public and private schools on St. Thomas. This year, through WAP II, the Program expanded to additional schools on St. John and St. Croix, reaching more than 600 students.

Methodology

The goals of the in-school Water Ambassador Program are to: (1) create awareness of and to reduce nonpoint source pollution, (2) bring attention to the importance of water quality and the need for water testing in schools, homes and the community, and (3) encourage and promote understanding of watersheds. These were accomplished through the development of a model educational program, the installation of weather stations at each participating school, and the creation of online, web-mapping applications that allowed students to report observations about their landscape and to see the watershed observations made by others.

In its second year, the goal of WAP II was to enhance and expand this model program. This year, five schools on St. Thomas, five schools on St. Croix, and two schools on St. John participated in the WAP. In addition, several changes were made to the program. Youth and teachers were trained to set up and install the Davis Weather Stations. This was accomplished by utilizing the faculty and students of the University of the Virgin Islands (UVI) who had experience previously installing the weather stations and working with the web interface. Teacher training took place in June 2016 with more than 12 teachers from public, private and home schools in the Territory coming together with other faculty and staff from UVI to learn more about the WAP II and weather station installation. The teachers took part in mapping

training, using geographic information systems modeling software, and lab discussions for experiments that were completed during the school year and at the University of the Virgin Islands. Teachers were also taken on tours of the University's gardens and facilities to showcase aquaponics and hydroponic systems, to increase knowledge and interest in this water resource application.

As a result, WAP II successfully installed seven, new weather stations on St. Croix (5) and St. John (2; Fig 1). Each weather station and its associated online reporting page are available to the public through UVI's GeoCAS website to the general public (geocas.org). Students also gained additional experience in communicating science in this year's program. Students taped radio interviews and public service announcements (PSAs) for WUVI (a student-run radio station at UVI). Youth were taught science communication best practices so they could further their ability to share what they learned with their peers in the classroom, at school-based assemblies, and to the public.

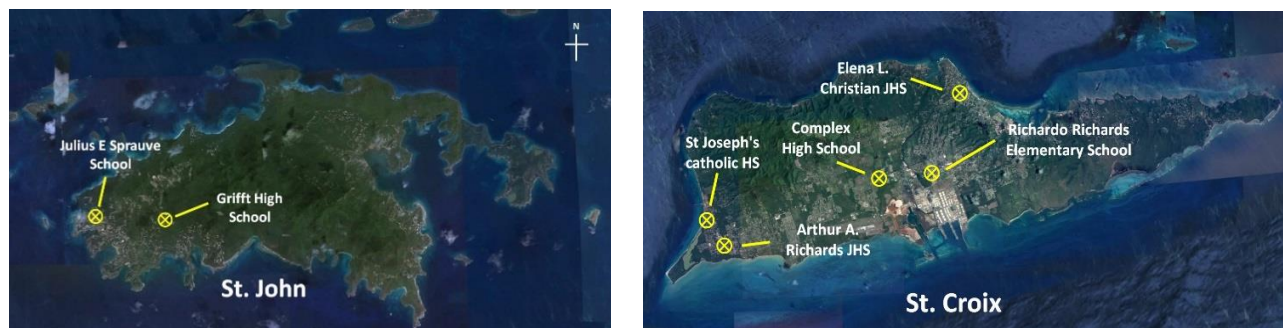


Fig 1. Map showing the locations of schools on St. Croix and St. John that had new weather stations installed as a result of WAP II.

Principal Findings and Significance

More than 670 students in the 4th through 12th grades and 12 teachers participated in the WAP II from nine private and public schools on St. Thomas, St. Croix, and St. John (Fig 2). These included English as a second language (ESL) students. The goal of the Water Ambassador Program is to advance hydrologic literacy of students, teachers and the general public across the Territory, specifically in the areas of water conservation, water quality, water resources and their management. Students who participated in WAP II were involved in and presented on water, water quality and landscape conservation practices, contributed to a system for collecting crowd-sourced data on the status of hydraulic systems in the Territory, reported on the status of their own watersheds, increased the total number of operational weather stations in use around the Territory, and shared what they learned with peers and the general public via video and radio (Fig 3).

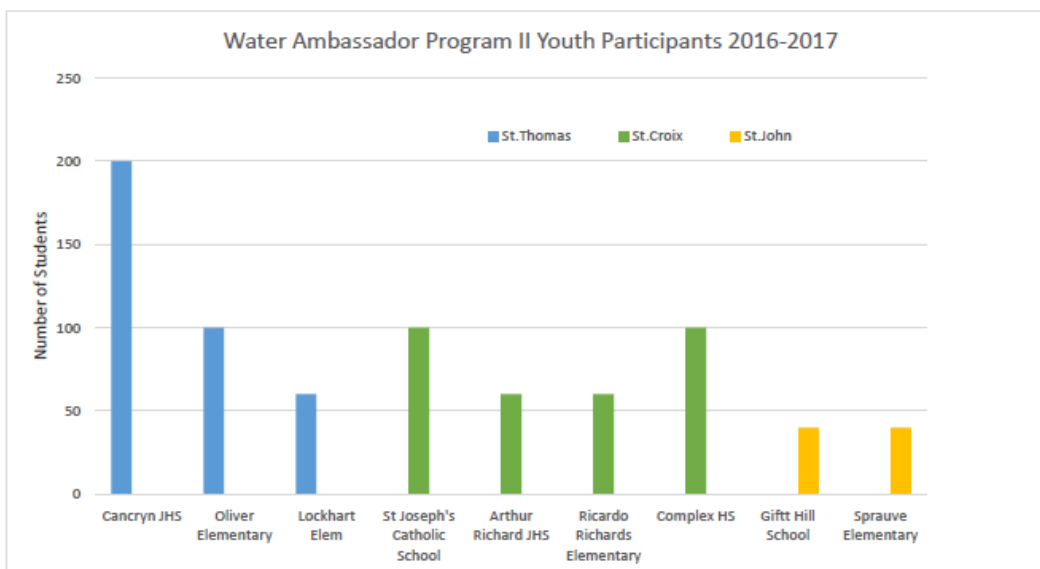


Fig 2. Number of students per school by island.



Fig 3. Student participants in the WAP II. An Addelita Cancryn Junior High School youth learning about water filtration during a hands on lesson (left) and St. Joseph's Catholic School seniors taking part in GIS lessons during WAP instruction at their school (right).

At the June training, 12 teachers and 15 students were trained to install the weather stations, read the display modules and use the information in daily and weekly announcements at the schools and in classrooms. In total, seven weather stations were installed at five schools on St. Croix and two schools on St. John (Fig 1), greatly expanding the USVI weather station network. St Joseph's Catholic High School in St Croix was the first "test" site which allowed youth to actually install and set up the weather station system (Fig 4). This was significant as it was vital that researchers have the opportunity to evaluate if vocational training for weather station installation could be undertaken by youth and become successfully operable. This was

completed in a one day activity at the school where approximately 20 high school youth from St. Joseph's Catholic School, prepared the site, installed the station and were able to determine that it was working on the other end by working with WAP staff and connecting to the research team in St. Thomas. In addition, youth at Elena Christian Junior High School were able work with WAP staff to learn about the routine station management methodologies that are critical to providing long-term, sustainable, USVI microclimate observations. They also photographed and sent pictures to WAP staff so as to ensure it was transmitting to the main Davis system as analyzed by UVI researchers. This train-the-trainer model is a vital component to the long-term sustainability of the WAP.



Fig 4. Installation of the St. Joseph's Catholic School weather station on St. Croix.

Participating students gained practical experience in science communication as a result of WAP II (Fig 5). For example, in April 2016, youth from the WAP in grades 4th-8th presented at the Virgin Islands Experimental Program to Stimulate Competitive Research Annual Conference on the program and water testing findings which came from their work in the program. At the event, their work and research was presented in English and Spanish to more than 100 guests including the public at large, teachers from the K-12 system, researchers, and UVI professors and students. Further, more than 30 students presented at the U.S. Environmental Protection Agency Science Consortium Meeting held in January 2017, to professionals from a variety of government agencies, community groups and professors from UVI. Large and small scale assemblies at many of the school sites across the Territory have been a part of the WAP II this year in an effort to share what the WAP youth have learned with the broader school community. Students have also shared what they've learned with the broader Virgin Islands community through taped radio interviews and PSA's for WUVI, the student-run radio station at UVI.



Fig 5. Students from Addelita Cancryn Junior High School present at the US EPA event held in January 2017 (left). Dr. Stan Latesky and Lockhart Elementary School youth talking on air at WUVI about the WAP II (right).

The Water Ambassador Program has been shared nationally and internationally and received national recognition. In May 2016, Chanes and Primack went to the annual eXtension Conference held in San Antonio, TX where they presented on the WAP to a national audience. In July 2016, the WAP was highlighted at the 4H Film Fest in Missouri where a student-created film was featured on the big screen for peers from five states to see and evaluate. Chanes also presented a poster on the WAP at the 52nd Annual Caribbean Food Crop Society held in Guadeloupe. Chanes gave an invited talk on WAP at the 62nd Annual Meeting of the Interamerican Society for Tropical Horticulture in Puerto Rico in August 2016. In April 2017, Chanes was awarded a 2017 U.S. Environmental Protection Agency (EPA) Environmental Champion Award from the EPA, Region 2, for her work on the Water Ambassador Program.

Other notable program outcomes include the construction of a WAP Outdoor Hydrologic Learning Center at the Addelita Cancryn Junior High School which was built out to include two greenhouses and several raised beds for the youth to test water and soil in the agricultural products they will grow there. Many of the youth that participated in the WAP program are now applying to summer STEM programs including the USDA-sponsored Ag Discovery and UVI's Youth Ocean Explorers program. In addition, several graduates are actively applying for the Math Behind the Science and the UVI Summer Business Programs. Finally, the program continues to highlight STEM career paths by partnering with UVI College of Science of Math faculty and a local private business.

Conclusions

The Water Ambassador Program II continues to fill an important role in the U.S. Virgin Islands by providing water resource curricula, authentic research experiences, and exposure to STEM career paths. This year, WAP II expanded to the islands of St. Croix and St. John in addition to St. Thomas, allowing more than 600 youth in grades 4-12 to participate in the program.

References

- Allen, W. H. 1992. Increased dangers to Caribbean marine ecosystems. *Bioscience*: 330-335.
- Thomas, Toni, Barry Devine. 2007. *Island Peak To Coral Reef*, VI, University of the Virgin Islands. Pg. 9.

USVI BER 2012. <http://www.usviber.org/November%202012.pdf> retrieved, December 3, 2014.

List of Presentations

PI/co-PI presented at eXtension in San Antonio, TX, March 2016
PI presented WAP NINJA Communications Workshop, STT, April 2016
4H Youth presented WAP at UVI EPSCoR Annual Conference, April 2016
PI presented at CSCF in Guadeloupe, FWI, July 2016
4H Film Fest Kansas City, MO, August 2016
USVI Drought Monitor User Forum, STX, August 2016
62 annual Horticulture Conference in Anasco Puerto Rico, September 2016
EPA Region 2 Science Consortium Meeting, St Thomas, January 2017

Student Participation

- Calywn Morton (Undergraduate), University of the Virgin Islands, Biology

Other

<https://soundcloud.com/wuviam1090/jnisa-a-water-ambassador>
<https://soundcloud.com/wuviam1090/christina-chanes-water-ambassador-2>
<https://soundcloud.com/wuviam1090/christina-chanes-water-ambassador>
<https://soundcloud.com/wuviam1090/ces-whats-going-on-water-ambassador-program>
<https://soundcloud.com/wuviam1090/the-kick-festival-segment-of-the-august-of-the-eye-on-the-vi-082616>

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	4	0	0	0	4
Masters	10	0	0	0	10
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	14	0	0	0	14

Notable Awards and Achievements

In December 2016, the USVI Drought Workgroup, comprised of individuals from the VI WRRI, the University of the Virgin Islands, and a local business, sent a letter to the U.S. Secretary of Agriculture, Tom Vilsack, to support the USVI's experimental inclusion in the U.S. Drought monitor. From August-December 2016, the USVI Drought Workgroup compiled available weather station data and calculated monthly, standardized precipitation indices (SPI) for the eight active, global historical climatology network (GHCN) weather stations that are available for the USVI (4 on St. Croix, 2 on St. John, and 2 on St. Thomas) for the period of 1980-2015. In January 2017, the USVI Drought Workgroup received a letter from Robert Johansson, Chief Economist at the U.S. Department of Agriculture in support of this goal. Currently, the Workgroup is developing an automated application program interface to capture these data to perform necessary SPI calculations with the goal of experimental inclusion in the U.S. Drought Monitor with the support from the Virgin Islands Department of Agriculture and Congresswoman Plaskett.

Christina Chanes, received a 2017 U.S. EPA Environmental Champion Award from the Environmental Protection Agency, Region 2, for her work on the Water Ambassador Program.

Publications from Prior Years

1. 2013VI244B ("Groundwater Chemistry, Flowpaths, and Flux Rates in the Mangrove System Surrounding Bovoni Landfill Within the St. Thomas East End Reserve (STEER)") - Articles in Refereed Scientific Journals - Keller, Jessica; Kristin Wilson Grimes, Andrew S. Reeve, and Renata Platenberg, 2017, Mangroves buffer marine protected areas from impacts of Bovoni Landfill, St. Thomas, United States Virgin Islands, Wetlands Ecology & Management, doi:10.1007/s11273-017-9536-0